ITEM No. 1, 9 & 21
FILE No. XXVIII—31

THE X-RAY INDUSTRY IN GERMANY

COMBINED INTELLIGENCE OBJECTIVES
SUB-COMMITTEE

FINAL REPORT ON THE INVESTIGATION
OF THE X-RAY INDUSTRY IN GERMANY

Reported by:

CAPERTON B. HORSLEY, U. S. Civilian

on behalf of the

U.S. Technical Industrial Intelligence Committee

CIOS Target Nos.
1/132e, 1/144, 1/246, 9/37, 9/147, 21/180
Radar
Physical & Optical Instruments & Devices
Metallurgy

August 11, 1945

COMBINED INTELLIGENCE OBJECTIVES SUB-COMMITTEE
G-2 Division, SHAEF (Rear) APO 413

TABLE OF CONTENTS

Personnel of Team

CAPERTON B. HORSLEY, U. S. CIVILIAN

GENERAL:

This report is based on information obtained during an investigation of the German X-Ray industry and associated industries. This investigation started in Leipzig on May 5, 1945, and was completed in Bad Oeynhausen on June 30, 1945.

In this report, no attempt is made to describe technical developments in detail, as these matters are covered in the special reports and other documents listed in the Appendix.

TECHNICAL DEVELOPMENTS:

Vacuum Tubes:

The most apparent German developments, trends and practices pertaining to the design and construction of X-Ray tubes for X-Ray equipment may be briefly described as follows:

1. End ground tubes with long electron beam paths, with and without magnetic focusing, in the range of from 45 to 200 Kv.P.

   Most of the tubes used for industrial radiography or fluoroscopy were end ground, magnetically focused, and water cooled. Tubes of this type were made by Siemens, Muller, and A.E.G. The rating for most of these industrial tubes was 150 Kv.P. at from 10 to 20 ma., continuously.

   Siemens also made a line of end ground tubes in the 45 to 100 Kv.P. range for contact (orificial) therapy. These end ground therapy tubes generally had transmission targets, were water cooled, and did not require magnetic focusing.

2. Very effective use of hooded anode construction.

   By thus preventing secondary electrons from accumulating and building up a charge on the inner glass walls of the tube, and by effective construction and processing methods, Siemens has succeeded in producing some types of tubes that are appreciably smaller in size than tubes made in the United States with equivalent ratings. This is particularly apparent in their 300 Kv.P., 30 ma. tube. Incidentally, this 300 Kv.P. tube has a heavy copper-tungsten hooded anode which reduces the external X-Ray shielding required from 8 mm to 4 mm of lead.

Not only does this extensive use of "almost completely" hooded anodes often make it possible to reduce the over-all weight of the tube head, but also this practice tends to improve radiographic and fluoroscopic quality because of the decrease in stem radiation and secondary radiation from the tube walls, the insulating oil, etc.

Most Siemens tubes used beryllium windows in their hooded anodes, whereas Muller did not use beryllium windows in most of their tubes that operated at less than 120 Kv.P. Muller reported that they did not feel that the improvement in electron shielding in their lower voltage tubes was sufficient to warrant the additional expense of beryllium windows.

3. A new Siemens process for coating steel balls with graphite for use in rotating target tubes.

This process was reported to provide a longer life than the previously used process for coating steel balls with graphite.

4. A new Muller process for coating steel balls with lead, for use in rotating target tubes.

5. The use of thoriated tungsten filaments on a few valve tubes up to 120 Kv.P., by both Siemens and Muller.

It was reported that by using thoriated tungsten filaments, they had succeeded in reducing the filament wattage to about 15% of the wattage required for pure tungsten filaments, but because of the processing difficulties involved, most valve tubes were still being manufactured with pure tungsten filaments, even though a longer life was expected with the thoriated tungsten.

6. The construction of at least one experimental end ground tube with a 30 cm diameter focal spot for superficial therapy at 100 Kv.P., or lower.

Even though many German X-Ray tubes use beryllium windows in their hooded anodes, no one in Germany has yet produced vacuum tight beryllium windows on a production basis. Accordingly, Lindemann Glass windows are used for diffraction and other low voltage tubes. For tubes to be used at 10 Kv.P. the Lindemann glass window is approximately .06 mm thick, and the beryllium window of the hooded anode .1 mm thick.

The beryllium used for hooded anode windows is as pure as they can obtain: about 99.8% beryllium, .1% iron, with most of the remaining .1% being crucible material. It was reported that Dr. Deisinger of Siemens, in Berlin, has done a considerable amount of work on the problem of increasing the purity of beryllium.

Two diffraction tubes with titanium targets were recently made by Siemens for Prof. Glocker, the German "iron-expert" in the Kaiser Wilhelm Institute at Stuttgart.

To make chromium targets, Siemens electroplates chromium to a thickness of 1 mm, then copper plates, and then silver solders to the copper anode. However, they still have trouble with chromium targets cracking.

Siemens used magnetic focusing on one of their diffraction tubes and obtained an effective focal spot size of 1 mm square with a 6-degree target. This tube was operated at 45 Kv.P. and 20 ma. continuously. On other more or less experimental tubes, Siemens has obtained effective focal spots as small as .2 mm by the use of magnetic focusing and constant potential on the focusing coil and across the tube. They reported that they were able to operate continuously at 1 ma. and 50 Kv.P. with this .2 mm focal spot.

For transmission targets, Siemens electroplates gold on copper. For 150 Kv.P. the gold is approximately .02 mm, and the copper 1.5 mm thick.

Siemens frequently use columbium (niobium) in place of tantalum in X-Ray and valve tubes. In Germany, columbium was cheaper than tantalum, as it was a by-product of their tantalum refining process.

Siemens and Halske in Berlin produced a 300 Kw. water cooled broadcasting tube(for frequencies up to 300 megacycles), with a semi-indirectly heated tantalum emitter. The heater wattage was reported to be between 30 and 40 Kw.

Most Siemens tubes use copper-glass seals. Muller uses "Kovar" with hard glass and chrome-iron with soft glass. Most "electric glass" was produced in Jena. Siemens used a special platinum glass with a de-coloring agent for some of their low voltage air insulated tubes.

A 300 Kv.P., 1000 ampere (10^{-7} second) cold cathode tube was developed by Prof. Herz of Siemens and Halske in Berlin, and was used at the University of Nurnberg for the industrial radiography of fast moving parts. Prof. Muehlenkfort was reported to have done a considerable amount of work with this tube.

It might be mentioned that for a number of years Siemens has made a comparatively small (about 3½ feet long) single section 600 Kv.P. X-Ray tube which is air insulated at atmospheric pressure.

As a matter of "vacuum tube interest:" It was reported that Dr. Bowers left the Philips (Eidhoven) organization in 1939 or 1940 after a series of arguments with the management over the Metalix tube design. The management, because of recommendations from the sales department, wanted to discontinue the air insulated Metalix design and go into the oil immersed tube design. It is understood that after the management won this argument, Dr. Bowers purchased a small optical company in Delft.

Some of the industrial X-Ray tubes used by Seifert had two ports, and at least one tube had three ports, so that two or three parts could be radiographed or fluoroscopically examined at the same time. With the end ground tube having the right angle target, a dozen or more parts were often radiographed at one time.

Muller reported that their X-Ray and valve tube developmental work since 1938 could be summarized as follows:

1. Work on end ground industrial X-Ray tubes.

2. Design of a number of oil immersed tubes, since their policy was to change from air insulated to oil insulated tubes.

3. Development of two new rotating target tubes, which were oil insulated and similar to U. S. design.

4. Development of a 300 Kv.P. mercury vapor, oil immersed rectifier. (These rectifiers were used in their "cascade circuit" neutron generators, and required 200 cycles per second, or higher, for satisfactory operation.

X-Ray Equipment:

The two particularly outstanding X-Ray equipment developments seemed to be the exceedingly well worked out use of thick sections of built-up paper in the construction of high tension coils, and the development of unusually high voltage flexible cables.

Generally speaking, the practice at Siemens was to depend on paper instead of oil for high tension insulation, the oil being used primarily to impregnate the paper, prevent the absorption of moisture, and to provide cooling.

The unusually high voltage flexible cable construction permitted the use of flexibly connected end ground tube heads at 200 Kv.P. and higher. One flexible cable, about $2\frac{1}{2}$ inches in diameter, could be operated continuously at 300 Kv.P., D.C., between the center conductors and the outside ground sheath. This cable made use of two concentric semi-conducting pathes,"to reduce the extension of voids."

Siemens had recently developed, but not put into production, an automatic system for use with photofluorography. This system automatically compensated for variations in line voltage, tube emission, and chest thickness and density, making use of a specially constructed ionization chamber which covered the entire film field.

Siemens had also developed, but not yet put into production, a particularly compact 4 valve, oil immersed, transformer and control unit for 100 Kv.P. and 400 ma. During the past several years, they had developed and put into production an unusually light weight 75 Kv.P., 25 ma. transformer and tube head, a small army field unit for use with this head, and a new tube stand arrangement for their larger army field unit. Work was being done by Zeiss at Jena on the development, for Siemens, of an improved optical system for photofluorography.

Muller has recently developed, but not yet put into production, a 100 Kv.P., 80 ma., diagnostic unit, and also a 150 Kv.P., 30 ma. unit for industrial radiography and fluoroscopy. In 1940 they brought out an oil immersed dental head to replace their compound filled head.

Muller also reported that it had been necessary for them to make many changes in equipment design in order to permit substitution of materials, because of restrictions on the use of certain materials for X-Ray apparatus, during the past several years.

Other Electro-Medical Equipment:

During the past several years, Siemens has done a considerable amount of developmental and experimental work on a supersonic frequency unit for the treatment of certain nerve conditions. In this unit a piezo-electric quartz crystal generates a frequency of about 800,000 cycles. Only a few models of this have been produced.

In 1942, Siemens started production of a high frequency "metal searching" unit for determining the location and position of a metal object to be removed from the body. This unit has been used extensively by the medical corps of the German army.

In 1942, Siemens also started production of a "new and improved Konvulsator" for administering electrical shock treatment for schizophrenia, etc. They have now produced a total of about 200 of these units.

Ultra High Voltage Equipment:

C. H. F. Muller A.-G., working in cooperation with, and under the direction of, the M. V. Research Association (M. V. Forschungs-Vereign), at Wrist, completed the construction of a 15 megavolt betatron about the first of this year. This betatron operates on 50 cycles. The average current of the high voltage electron beam is approximately .03 microamperes. The output of gamma radiation was reported to be approximately equivalent to one kilogram of radium. This betatron is now installed at Wrist.

In December, 1944, the M. V. Research Association completed the calculations and layouts of a 200 megavolt betatron, to operate on 50 cycles. It was estimated that the average electron beam current of this betatron would be in the order of one milliampere. The total weight was expected to be approximately 30 tons. This betatron was to be constructed by Brown Boveri and Cie A.-G. in Heidelberg. It is understood that Brown Boveri completed detailed construction drawings of this betatron about the first of March of this year.

Dr. W. Müller, of C. H. F. Müller, recently constructed a very small 2 megavolt betatron which weighed less than 100 pounds. This betatron operated on 50 cycles and had a sealed off tube but the output was only sufficient to increase a Geiger counter to about three times its normal rate.

Two betatrons had recently been constructed and were being tested at the Siemens-Reiniger plant in Erlangen. The first of these betatrons to be completed operates on 500 cycles and provides an electron acceleration of 6 megavolts. The second, most recently constructed, betatron operates on 50 cycles and provides an electron acceleration of 7 megavolts. Plans were being made at this plant to construct a 50 cycle, 15 megavolt betatron. Siemens reported that their particular interest in betatron development was in order to provide a means for experimental work with electron beam cancer therapy.

Prof. Bierman of A.E.G., in Berlin, was reported to be working on the design of a 20 megavolt betatron.

During the past two years, C. H. F. Muller has constructed and delivered five "neutron generators". Three of these were rated at 1.5 megavolts, one at 1.2 megavolts, and one at .9 megavolts. They have on order, but have not yet completed, one additional neutron generator rated at .9 megavolts and another rated at 2.4 megavolts. These "neutron generators", or "deutron accelerators", accelerate ionized heavy hydrogen against a beryllium or a lithium target. The neutron output at .9 megavolts when using a beryllium target was estimated to be equivalent to the neutron output of 2 kilograms of radium plus beryllium; when using a lithium target, 3 kilograms; when using a beryllium target at 1.5 megavolts, 13 kilograms; when using a lithium target, 8 kilograms.

The Phillips "cascade" circuit was used for these neutron generators. Although the electrical output of these generators could be as high as 5 ma., the ion source limited this equipment to 0.8 ma. for continuous operation, regardless of voltage.

At 0.8 ma. the ripple was about 1%, at 5 ma., about 5%.

The following Van de Graaff type generator installations were reported:

1. Kaiser Wilhelm Institute, Heidelberg: 1 megavolt at 1 ma. Used by Prof. Bothe for positive ion acceleration.

2. Tech. Hochschule, Danzig: 1 megavolt. Used by Prof. Kassel.

3. Haukeland-Krankenhau, Bergen, Norway: 1.5 megavolts at 2 ma. Used by Dr. Von Odd Dahl and Dr. B. Trumpy.

4. Charkow, Russia: "3 or 4" megavolts.

5. Curie Institute, Paris.

Cyclotron installations were reported as follows:

1. Siemens and Halske, Berlin: A large cyclotron being constructed under the supervision of Prof. Herz. Hertz

2. Curie Institute, Paris: "Largest cyclotron on the continent". Constructed under supervision of Prof. Bothe during German occupation.

3. "Niels Bohr", Kopenhagen.

4. Russia: "Three or four, or more" cyclotron installations were reported to be in Russia.

The only resonant transformer installation reported to be in use in Germany was a 600 Kv.P. installation used for demonstration at the University at Kiel.

Industrial X-ray Techniques:

In Germany the most frequently used industrial X-ray units are end grounded, magnetrically focused, and are generally rated at 150 Kv.P. and from 10 ma. to 30 ma., continuously. These units have made it possible to work out many new industrial radiographic and fluoroscopic techniques.

When using an end ground tube having a long anode extension it is possible to locate the focal spot in otherwise inaccessible internal positions in castings or welded assemblies.

Because of the adjustable focal spot size it is often possible to use closer target to film distances than would otherwise be feasible. Because of the "360° port" of the end ground tube with the right angle target, many castings can be radiographed, or fluoroscoped, at one time, or a circumferential weld can be radiographed with one exposure.

Most German industrial radiographic units do not exceed 200 Kv.P. although a few 300 Kv.P., and some 400 Kv.P. industrial radiographic installations have been made. For steel thicker than 7.5 inches radium (mesothorium) was used. Thick sections were also inspected with supersonic frequencies, generally using 20 to 30 thousand cycles, and never more than 100,000 cycles. In addition to magnetic arrangements for testing rails, the "magnetic-field-iron-filings-in-oil-bath-photographic" method was also reported to be in general use for detecting surface or sub-surface flaws in castings or other metal parts.

Work was recently done in Germany on coloring, or changing the color, of precious stones by X-ray radiation. However, it was found that many gems reverted to their original color after prolonged exposure to sunlight.

Medical X-ray, and Other Electro-Medical, Techniques:

Because of the development, and production, of a number of end ground, "orificial cavity" tubes, the German radiologists have worked out many new contact therapy techniques and have obtained a very considerable amount of pertinent clinical data.

During the past several years more frequent use had been made of heat, by high frequency, in combination with X-ray therapy for cancer. It was reported that an increase in temperature increased the sensitivity of cancer cells but did not appreciably increase the sensitivity of normal cells. This technique was "discovered" in 1929, but was not "proven" until some time in 1941.

Siemens reported that their primary interest in betatron development was in order to provide a means for experimental work with electron beam cancer therapy. They felt that something in the order of 15 million electron volts would be required.

One radiologist was doing experimental work with a 100 Kv.P. tube having a 30 cm diameter focal spot in order to eliminate cross firing for light therapy.

The lowest voltage X-ray work done in Germany was reported to be at 10 Kv.P. for some skin therapy techniques.

Siemens production figures seem to indicate a trend toward higher milliamperage,up to 2000 ma., for radiographic and photofluorographic work.

Siemens, in collaboration with various clinics, has worked out new supersonic frequency techniques for treatment of certain nerve conditions, and also new electric shock therapy techniques.

In collaboration with German army doctors, Siemens has also worked out new foreign metal object locating techniques, using their high frequency "Metal-Searcher",sometimes in combination with fluoroscopy or a previous radiographic examination.

SOURCES OF SUPPLY:

Following is a list of the German sources of supply for most of the special materials and products required for the production of X-Ray tubes and equipment:

1. Tantalum: Siemens and Halske, Berlin, was the only producer of tantalum in Europe. Note: All of the tantalum ore used in Germany originally came from Australia. About 1939 Dr. Kolligs of Siemens and Halske, in Berlin, developed an economical method for refining tantalum from the large amount of refuse that had been accumulated from the previously used refining process. Because of this there was no shortage of tantalum in Germany.

2. Columbium: Siemens and Halske, Berlin. Note: With Kollings' refining process mentioned above columbium (niobium) was also recovered, as a by-product, from the "refuse tantalum ore." Columbium was often used in place of tantalum, since it has many of the characteristics of tantalum and was considerably cheaper.

3. Beryllium: Heraeus Vacuum Schmelze, Hanau (near Frankfurt au Main). Also: Degussa, Frankfurt au Main. Note: Heraus was owned by Siemens. It has been destroyed, and the two chief directors killed. Degussa supplied beryllium to Muller.

4. Tungsten: Osram, Berlin. Also, Deutsche Edelstahl Werke, Berlin, factory in Reuthe in Tyrol, Austria.

5. Molybdenum: Same as above.

6. Glass: Schott and Genossen, Jena. Also: Glaswerk Fischer, Ilmenau. Also: Osram, Weisswasser (near Berlin) Also: Glasfabrik Weisswasser G.m.b.H., Weisswasser (owned by Phillips).

7. Oxygen free copper: Siemens and Halske, Berlin and Vienna. Also: Oxygen free copper sheet from Heraus in Hanau.

8. Transformer Oil: Rhenania-Ossag, Hamburg.

9. High Tension Cable: Siemens-Schuckertwerke Kabelwerk, Gartenfeld bie Siemensstadt, Berlin. Also: Kabel-

werk, Rheydt (near Holland). Note: Siemens-Schuckert made flexible cable up to 300 K.V.P., D.C., between the center conductors and the ground sheath.

10. Special, High Resistance, Wire: Dr. Schildbach Rheinische Feinstrahrindustrie, Bergneustadt, Rheinland. Note: This firm produced a spiral wound resistance wire imbedded in flexible insulation, so that the over-all "wire" diameter is less than one-eighth of an inch. The rating of this wire is 15 wat per meter in free air. The rating in oil is somewhat higher. The maximum resistance rating is 2 megohms per meter, but in order to obtain satisfactory performance with long lengths, .9 megohms per meter should not be exceeded.

11. Insulating Papers: Note: Insulating papers were obtained from a number of different sources, but it was reported that none of these papers were as good as the insulating paper previously obtained from Finland.

12. Insulating Liquids Other Than Oil: Note: Siemens reported using a liquid for condensers having a high dielectric constant, from 80 to 120, known as "Condensa", and manufactured by Hescho, in Hermsdorf. This is possibly titanium-dioxide. They also used a similar liquid known as "Frequenta" which was produced in Lauf, near Nurnberg. This is possibly steatite-magnesia.

13. Fluoroscopic and Intensifying Screens: Siemens-Reiniger, Rudolstadt. Also: Heyden, Dresden. Also: Auer, Berlin.

14. Special Paint: Note: I. G. Farben, Frankfort, has developed a paint which changes color with temperatur. Muller was considering the use of this paint on tube heads to warn of overheating.

ORGANIZATION, PRODUCTION, AND GENERAL INFORMATION:

Siemens-Reiniger-Werke A.-G., Rudolstadt:

This organization is the largest European manufacturer of X-Ray tubes and valve tubes for X-Ray equipment.

As of March, 1945, they had 550 employees. About 50 were engaged in the production of fluoroscopic and intensifying screens and other "X-Ray Chemicals," and 100 were producing small amplifying and detector tubes, as part of their "war work" program. The remaining 400 were involved in the design and production of X-Ray tubes and high voltage valve tubes for X-Ray equipment.

The plant is well equipped and had not been damaged. This organization did its own research and engineering work for all of its X-Ray products.

The following persons were interviewed at this plant:

Dr. Albrecht Wölfel, Chief Director.

Dr. Theodor Zimmer, Head of Physical Research Laboratory and X-Ray Tube Development.

Dr. Josef Hartman, Research and Production Manager of Chemical Department.

Mr. Walter Döhler, Business Manager.

Mr.Hans Frank, Sales Manager.

Dr. Werner Jacoby. Note: Dr. Jacoby was recently evacuated from Vienna, where he had been in charge of research and development for all Siemens and Halske vacuum tubes, except X-Ray tubes and valve tubes for X-Ray equipment. Siemens-Reiniger is the only one of the many manufacturing organizations owned or controlled by Siemens and Halske.

The following figures will indicate the monthly production of this plant as of March of this year:

X-Ray Tubes.	800
Valve Tubes (for X-Ray equipment). .	200
Intensifying Screens	1,100 sq. ft.
Fluoroscopic Screens	120 sq. ft.

Of "Non-X-Ray Products:

Amplifying (repeater) Tubes.	6,000
Small gas filled detector tubes. . .	20,000
Gas filled surge protecting tubes for communication lines.	20,000

Siemens-Reiniger-Werke A. - G., Erlangen:

This organization designs and manufactures X-Ray apparatus and other electro-medical equipment. Tubes are supplied to Erlangen by the Rudolstadt plant.

During the past several years this plant has manufactured, but not designed, some assemblies and parts for aircraft radio, instrument, and control equipment.

The plant is well equipped, and although there had been some damage by looting, there had been no bomb damage.

Up to the time of occupation this plant had about 3000 employees, approximately one-third of which were working on "war work" (aircraft radio assemblies, etc.), another third on X-Ray equipment, and the remaining third on other electro-medical equipment. During 1944, there was an average total of about 6000 employees in all Siemens-Reiniger organizations, including sales and service personnel.

This plant has a total floor area of approximately 400,000 : 37161,22 m² square feet. As of the first of this year, the total monthly payroll was about 450,000 marks.

The following persons were interviewed at this plant:

Dr. Max F. Anderlohr, Chief Director of both Erlangen and Rudolstadt plants.

Dr. Johannes Patzold, Chief of Research & Development Laboratories.

Mr. Kurt Bischoff, Chief of X-Ray Development (under Patzold).

Dr. Walter Hoffman, Chief of Patent Department of both Erlangen and Rudolstadt plants.

Mr. Karl Silbermann, Liaison Officer on X-Ray and valve tubes between Erlangen and Rudolstadt plants.

Dr. Theo. Sehmer, Sales and Service Manager.

Dr. Karl Lasser, Technical Director of Sales and Service.

Dr. Albert Marcus, M.D., Specialist on "Electrical Medicine."

(Sehmer, Lasser and Marcus were recently evacuated from the Siemens-Reiniger Berlin Office).

The average production of this plant during the past year is indicated below:

A. Transformer & Control Units for Therapy:

1200 Kv.P.-5 ma., per year. 1

400 Kv.P.,5 ma., per year. 3

200 Kv.P.,30 ma., per month. 12

120 Kv.P.,8 ma., per month 3

60 Kv.P.,5 to 8 ma. for Contact Therapy, per month. 3

B. Transformer & Control Units Primarily for Radiography & Fluoroscopy, but Occasionally Used for Superficial Therapy:

100 Kv.P., 2000 ma. (Condenser Discharge), per month 2

100 Kv.P., 1000 ma. (3 phase) per month . . . 3

120 Kv.P., 800 ma. (full wave) per month . . 4

120 Kv.P., 400 ma. (full wave) per month. . . 16

120 Kv.P., 200 ma. (full wave) per month. . . 11

120 Kv.P., 80 ma. (half wave) per month . . . 23

90 Kv.P., 50 ma. (self-rectified) per month . 20

75 Kv.P., 25 ma. (self-rectified) per month . 15

60 Kv.P., 15 ma. (self-rectified, sphere, including Dental) per month... 150

C. Other X-Ray or Electro-Medical Units:

Photofluorographic Units, per month 8

H. F. Metal Searcher (Production started 1942. About 1000 units in all have been produced for the Army), per month. 30

Electrical Shock Treatment Unit (200 total since 1942) per month 7

Six Meter H. F. Diathermy Unit, (12,000 total since 1933) per month 150

H. F. Surgical Knife (all models) per month . . 15

One Meter H. F. Diathermy Unit (10 were made in 1937 and 1938; none since because magnetrons could not be obtained). 0

Cassettes (all sizes,) per month 800

Bucky-Potter Diaphragms, (moving grids) per mo. 75

Bucky-Potter Diaphragms (fixed grids) per month 180

Motor-Pantostat (Universal Electro-Medical Unit) per month 35

Mechanical Dental Machines, per month 120

D. Additional Equipment:

Note: Much additional X-Ray and electro-medical equipment was made at this plant, such as tube stands, tilting tables, vertical fluoroscopes, stereoscopes, etc.

C.H.F. Müller, A.-G., Hamburg-Fuhlsbuttel, Rontgenstrasse 24:

This company designed and manufactured X-Ray tubes and housings, valve tubes for X-Ray equipment, X-Ray equipment, and high voltage generators for deutron acceleration (neutron generators).

During the past several years they have also manufactured, in accordance with specifications supplied by other organizations, underwater sound equipment assemblies, low voltage aircraft electrical equipment sub-assemblies, and gas filled tubes for use in communications circuits.

As of the first of this year, Müller had approximately 500 employees. Of these, about 170 were engaged in the production of X-Ray tubes and housings and valve tubes for X-Ray equipment -

160 were working on X-Ray equipment,
65 on underwater sound equipment,
55 on communications tubes, and
20 on high voltage generators for deutron acceleration.

This plant has a total floor area of approximately 80,000 square feet. It is well equipped, and had not been damaged.

The following persons were interviewed at this plant:

Mr. Otto Gundermann, Administration Manager.

Dr. Werner Fehr, Assistant Manager.

Mr. Alfred Kuntke, Chief Research & Development Engineer.

Mr. Kurt Weigel, Manager of X-Ray Tube Division.

Mr. Arthur Lipphaus, Mechanical Engineer.

Mr. Adolph Hoffmann, "Construction" Engineer.

Up to the time of the occupation, Dr. Hans Ritz had been the Technical Manager, Dr. Walther Muller the Chief Physicist, and Mr. Wilhelm Daumann the Chief "Construction" Engineer, but, several weeks after occupation, all three of these men were dismissed on instructions from the Philips organization in Eidhoven. It was reported that these men were dismissed because they had been active members of the Nazi party.

The Muller production for the month of January 1945 was approximately as follows:

A. <u>X-Ray Tubes and Valve Tubes for X-Ray Equipment:</u>

Valve Tubes, 150 Kv.P. or higher	30
Valve Tubes, lower than 150 Kv.P.	100
End Ground X-Ray Tubes, 150 Kv.P. or higher, 10 to 20 ma., (about 50% of these were magnetically focused).	6.
End Ground X-Ray Tubes, lower than 150 Kv.P., (excluding diffraction tubes), rated at 10 ma. and not magnetically focused	2
Center ground therapy tubes, 200 Kv.P., 10 and 20 ma.	5
Center ground therapy tubes, 400 Kv.P., 6 ma. (They have made only 6 or 7 of these tubes during the past 10 years)	0
Center ground radiographic or fluoroscopic tubes:	
10 ma., 60 Kv.P., self rectified, oil insulated	40
15 ma., 60 Kv.P., self rectified, air insulated	50
80 ma., 100 Kv.P., including oil and air insulated tubes, but most of which were air insulated.	60
120 ma., 100 Kv.P., most of which were air insulated.	10
200 ma., 100 Kv.P., rotating target, most of which were air insulated	30
400 ma., 100 Kv.P., rotating target, most of which were air insulated	30
500 ma., 100 Kv.P., rotating target, oil insulated. (A total of only 3 or 4 of these tubes have been made).	1
Diffraction Tubes, all types	15
Gernst Ray 10 Kv.P., Tubes (only 3 or 4 of these tubes have been made during the last several years)	0

B. <u>Transformer and Control Units for Therapy:</u>

60 Kv.P., 2 ma., (10 were made in 1939. Only repairs during the past two years)	0
200 Kv.P., 10 ma., (10 were made in 1939. Only repairs during past two years)	0

C. <u>Transformer and Control Units Primarily for Radiography:</u>

10 ma., 60 Kv.P., self rectified, for dental and field work	35
40 ma., 100 Kv.P., self rectified, (made at Philips plant in Einhoven since 1939)	0
200 ma., 100 Kv.P., 4 valve (no production since 1939).	0
400 ma., 100 Kv.P., condenser discharge; (about 15 were made in 1940, no production since then). .	0

D. <u>Transformer and Control Units for Industrial Radiography and Fluoroscopy:</u>

150 Kv.P., 20 ma., (about 15 yearly)	1
300 Kv.P., 10 ma., (about 2 yearly).	0

E. <u>X-Ray Diffraction Transformer & Control Units:</u>

30 ma., at 50 Kv.P., (60 ma. at 25 Kv.P. for some targets)	3

F. <u>Other X-Ray Products:</u>

Simple Tube Stands, Dark Room Equipment, Cassettes, and other X-Ray accessories. (Other X-Ray equipment was made in Eidhoven or purchased by Muller, for resale, from other German manufacturers).

G. Other "Non-X-Ray" Products:

Neutron-Generators (five have been completed since 1943) . . . .

Gas filled rectifiers for communications circuits . 1500

Under water sound equipment, electrical aircraft sub-assemblies, etc. . . . .

Rich, Seifert & Company, Hamburg:

Seifert was the largest manufacturer of industrial X-Ray equipment in Germany. The output of this firm in industrial X-Ray equipment was three or four times as large as their medical X-Ray equipment output.

Seifert purchased tubes from Seimens, Muller, and A.E.G., and manufactured only a few pump connected tubes.

At the first of this year the total number of employees was about 350, and the total floor space occupied about 50,000 square feet.

Mr. Richard Seifert and several of his employees were interviewed.

The Seifert average monthly production as of January, 1945, was approximately as follows:

A. Pulsating (Villard) Transformer and Control Units:

125 Kv.P., 10 ma., end ground	1
150 Kv.P., 10 ma., end ground	2
150 Kv.P., 30 ma., end ground	1
250 Kv.P., 10 ma., center ground	6
250 Kv.P., 10 ma., center ground, arranged for alternate operation at 150 Kv.P., 1 ma., end ground, constant potential. (only 9 produced during last five years)	0
300 Kv.P., 10 ma., center ground	1

400 Kv.P., 6 ma., center ground. (One produced in 1940; none since then) 0

B. Constant Potential Transformer and Control Units:

150 Kv.P., 10 ma., end ground 1

150 Kv.P., 30 ma., end ground 1

200 Kv.P., 30 ma., center ground. 2

C. Four Valve Transformer and Control Units:

120 Kv.P., 40 ma. continuously, up to 500 ma. for short exposures, center ground 1

D. Six Valve, Three Phase, Transformer and Control Units:

120 Kv.P., 100 ma. continuously, up to 1000 ma. for short exposures. (Only two produced in last two years). 0

E. Diffraction Transformer and Control Units:

60 Kv.P., 30 ma., end ground 1

F. Special Units:

Note: During the past several years Seifert has constructed two 80 Kv.P., 5 ma., constant potential units; one 75 Kv.P., 1 ma., 500 cycle unit for use with electron microscope; one 100 Kv.P., 5 ma., 500 cycle unit for "laboratory purposes;" and ten or more 60 Kv.P., "fine structure" units. Seifert also produced a number of special tube stand and fluoroscopic arrangements for industrial work, and a few more or less standard tube stand and fluoroscopic arrangements for medical work.

Metallgussgesellschaft, Leipzig:

This plant produced light metal castings for aircraft engines including castings for the Jumo 109.004 jett engine. As of the first of this year, this plant had 3500 employees, and produced about 400 tons of aluminum and magnesium alloy castings per month.

Throughout the foundry there were ten separate X-Ray examination locations. Although much of the X-Ray equipment had been removed or destroyed by the management, the following observations may be of interest:

1. It seemed that each location had been composed of two or more radiographic installations. Several fluoroscopic installations were found.

2. In all, it appeared that from twenty to twenty-five radio - graphic installations, from three to five fluoroscopic installations, and from five to ten dark room installations, had been in use.

3. All of the equipment examined had been manufactured by Seifert, in Hamburg, and used A.E.G., 150 Kv.P., end ground, magnetically focused tubes.

4. It was reported that critical portions of every casting were examined either radiographically or fluoroscopically, and that the average figure for rejects was about 25%.

Siemens Organizations:

The "main seat" of the Siemens organizations was Siemens & Halske, A.-G., at Berlin. It was reported that this firm controlled or partially controlled the following organizations:

Siemens-Reiniger-Werke, Berlin, (with plants in Rudolstadt and Erlangen).

Siemens-Schuckertwerke, Berlin.

Siemens Plania Works, Berlin.

Siemens Building Company, Berlin.

Electric Light & Power Company, Berlin.

Electrical Plant Company, Berlin.

Gas & Electric Company, Berlin.

Southwest Electrical Power Company, Berlin.

Electrical Machinery Company, Berlin.

German Telephone & Cable Works, Berlin.

Heliowatt Electrical Works, Berlin.

R. Stock & Company, Berlin.

Dr. Cassirer & Company, Berlin.

United Railway Signals Works, Berlin.

"Inag" Industrial Undertakings Company, Berlin.

Elektrizitat-Aktiengesellschaft, Nuremburg.

Electrical & Street Car Company, Landsberg.

Zell Electricity Works, Wiesental.

Saal Electrical Power Company, Saalfeld.

Zoppet Electrical Power Company, Zoppot.

Jena Electrical Power Company, Jena.

Bavarian Electrical Power Company, Munich.

Thuringian Electricity Delivery Company, Gotha.

Greater Kassel Street Car Company, Kassel.

Electrical Exploitation Company, Glarus.

Electrical Plant Company, Basel.

Brunswick Industrial Company, Brunswick.

Austrian Siemens Schuckertwerke, Vienna.

In addition to the above, Siemens was reported to have "contracts and agreements" with the following foreign firms before the war started:

Afghanistan:	"Sita" Shoquenie Industriale Tregtare Company , Tirana.
Algiers:	Continental Electrical Company.
Argentina:	Siemens Schuckert Company, Buenos Aires
Austria:	Siemens & Halske, Vienna.
Australia:	New Systems Telephone Ltd., Sydney; also Golin & Company, Melbourne.
Belgium:	Siemens Company, Brussels.
Brazil:	Siemens-Schuckert, Rio de Janiero.
Britain:	Siemens-Schuckert Great Britain Company, London.
Bulgaria:	Siemens Bulgarian Electrical Company, Sofia
Chile:	Siemens-Schuckert, Antofagasta.
China:	Siemens China Company, Shanghai.
Colombia:	Curacao Business Company, Curacao.
Danzig:	Siemens & Company, City of Danzig.
Denmark:	Siemens Electrical Company, Copenhagen.
Dutch East Indies:	Siemens-Netherlands Company, Batavia.
Egypt:	Siemens Orient Company, Cairo.
El Salvador:	F. Giessler, San Salvador.
Finland:	Siemens Electrical Company, Abo.
France:	"Siemens France," Paris.
Greece:	Alexander Zachariou Technical Company, Athens.

Guatemala:	Tope & Company, Guatemala City.
Hungary:	Siemens Hungarian Electrical Company, Budapest.
Iceland:	Messrs. Paul Smith, Rejkjavik.
Ireland:	Siemens-Schuckert Ireland Company, Dublin.
Iran:	Shakrokh Brothers, Teheran.
Italy:	Siemens Company, Milan.
Japan:	Siemens-Schuckert, Tokio.
Letland:	Letland Siemens Company, Riga.
Lithuania:	A. Putrimas & Company, Kaunas.
Luxemburg:	Siemens & Company, Luxemberg.
Memel:	Messrs. A. Wittenberg, Memel.
Mexico:	"Siemens-Mexico," Asuncion.
Netherlands:	Siemens-Netherlands Company, s'Gravenhage.
Morocco:	"Siemens France," Casablanca
New Zealand:	Golin & Company, Wellington.
Norway:	Siemens Norwegian Company, Oslo.
Peru:	Hans G. Ritterman, Lima.
Portugal:	Siemens Electrical Company, Lisbon.
Portuguese-Guinea:	Ultramarina Company, Bissau
Rumania:	Eugen Behles & Company, Bucharest.
South Africa:	Siemens & Company, Johannesburg.
Spain:	Siemens Electrical Industries Company, Barcelona, Madrid, etc.
Sudan:	Siemens & Company, Tunis.

Sumatra:	Carl Schliepper Man. Company, Medan.
Sweden:	Siemens Company, Stockholm.
Switzerland:	Siemens Electrical Products, Lausanne.
Thailand:	B. Grimm & Company, Bankok.
Turkey:	Muhendis Tarnapol, Stamboul.
United States:	Siemens Incorporated, New York.
Uraguay:	Eugenio Barth & Company, Montevideo.
Venezuela:	Schnell & Company, Caracas.

N. V. Philips Gloeilampenfabrieken, Eindhoven, Holland:

The parent Philips organization is N. V. Philips Gloeilampenfabrieken, located at Eindhoven, Holland.

During the last part of 1944, the Eindhoven plant had about 15,000 employees. It was estimated that about 500 of these employees were working on X-Ray and other electro-medical equipment, 4,500 on airforce radio equipment, 5,000 on radio tubes, and 5,000 on incandescent lamps.

The Eindhoven plant not only produced substantially the same X-Ray tubes and equipment that were being manufactured at the Muller plant, but also higher powered transformer and control units, tube stands, tilting tables, quartz lamps, short wave diathermy equipment, etc.

Following is a list of the organizations which were reported to be owned and controlled by Philips as of 1944:

1. C. H. F. Muller Aktiengesellschaft, Hamburg. (Previously described in this report).

2. Philips Valvo-Werke G.m.b.H., Hamburg; also known as Radiorohrenfabrik G.m.b.H. (The Hamburg plant employed about 4,000 and manufactured radio tubes. This firm also had a plant in Aachen which produced radio sets, but this plant was destroyed by bombs in 1942. The sales office of this firm was in Berlin).

3. Studiengesellschaft für Elektronengerate G.m.b.H., Hamburg. (This organization functioned as the engineering and research department for the above mentioned radio tube plant at Hamburg. They were reported to have about 100 employees).

4. C. Kargen, A.-G., Berlin. (Manufactured machine tools. No estimate on number of employees).

5. Glasfabrik Weisswasser, G.m.b.H., Weisswasser/O.S. (Produced glass, particularly for vacuum tube requirements. About 200 employees).

6. Philips Elektro-Special G.m.b.H., Berlin. (Manufactured measuring instruments, cathode ray oscilloscopes, and other laboratory equipment. Also sold other Eindhoven products. About 300 employees).

7. Rectron G.m.b.H., Berlin. (Manufactured heavy duty mercury vapor rectifiers and also sold other Eindhoven produced rectifiers. About 100 employees).

The above figures indicate that the total number of employees of all of the European Philips organizations, as of 1944, was slightly more than 20,000.

<u>German X-Ray Industry:</u>

Following is a list of most of the manufacturers of X-Ray tubes and equipment in Germany, indicating the approximate number of employees, not including sales and service personnel, working on X-Ray products, as of 1944:

1.	Siemens-Reiniger-Werke A.-G., Rudolstadt, X-Ray Tubes and Screens	450
2.	Siemens-Reiniger-Werke A.-G., Erlangen, X-Ray Equipment	1,000
3.	C.H.F. Müller, Hamburg-Fuhlsbüttel, X-Ray Tubes and Equipment	330
4.	A.E.G. Röhnrenwerk Oberspree, Berlin, Oberschonweider Str. Industrial and Therapy X-Ray and valve tubes (Dr. Traub, Director of X-Ray Tube Production)	200

5. Radiologie Rontgenrohrenfabrik, A.G. Recently moved from Berlin to Gera, Admiral Scheer Str. 10, 100 Kv.P. Valve tubes for X-Ray Diagnostic Equipment. (Mr. Gloger, Director)	40
6. Otto Kiesewetter, Rudolstadt Valve Tubes for X-Ray Equipment	10
7. Koch and Stertzel, Dresden X-Ray Equipment and Valve Tubes	600
8. Sanitas, Berlin, Karlstrasse X-Ray Equipment and Dental X-Ray Tubes	200
9. Seifert, Hamburg, Herman-Behn-Weg 7-11 X-Ray Equipment for Industrial Radiography and Fluoroscopy	300
10. Ritter, Freiburg im Breisgan Dental X-Ray Equipment	250
11. Marhold, Vienna X-Ray Equipment (Primarily Fluoroscopic Tables)	50
12. Siemens and Halske A.-G., Berlin, Siemenstadt, X-Ray Equipment for Industrial Radiographic, Fluoroscopic and Diffraction work	300
Total	3,780

The four "most important" X-Ray physicists in Germany were reported to be:

1. Prof. Behnken, Physikalisch Technische Reichsanstalt, Berlin. (Dosemetry).

2. Prof. Friedrich, Institute für Strahlenkunde, Berlin. (Radiation research).

3. Prof. Grebe, Bonn. (Cloud Chamber work).

4. Prof. Kulenkampff, University of Jena. (X-Ray spectrum).

The most important radiologists and X-Ray clinics in Germany were reported to be:

1. Dr. Zimmer and Prof. Timofeef-Ressovsky, Kaiser Wilhelm Institute for Brain Research, Berlin, Buch. (Work on borderline of X-Ray physics and biology).

2. Prof. Langendorf, Radiological Institute Freiburg im Breisgan. (X-Ray physics and biology).

3. Prof. Chaoul, Charite, Berlin. (Low voltage therapy).

4. Prof. Holthusen, St. Georg Hospital, Hamburg. (Deep therapy and diagnostic work).

5. Stadtkrankenhaus, Frankfort. Prof. Holfelder died in 1944. (Diagnostic and therapy).

6. Prof. Wintz, Frauenklinik, Erlangen. (Therapy).

7. Prof. Knothe, Berlin. (Chairman of German Roentgen Society).

8. Prof. Grashey, Cologne University. (Diagnostic work).

APPENDIX:

Copies of the following documents, which were obtained in Germany, have been turned over to the Secretariat, C.I.O.S.:

1-A. Design and Manufacturing Information Regarding X-Ray Tubes and Valve Tubes for X-Ray Equipment:

1-A-1. Muller, 150 Kv.P., End Ground Industrial X-Ray Tube: Complete design and manufacturing drawings and specifications.

1-A-2. Muller, "Small," Oil Insulated Rotating Target Tube; complete design and manufacturing drawings and specifications.

1-A-3. Muller, "Large," Oil Insulated Rotating Target Tube: complete design and manufacturing drawings and specifications; including vacuum ball bearing processing data.

1-A-4. Muller, "Festanoden," Oil Insulated Radiographic Tube: complete design and manufacturing drawings and specifications.

1-A-5. Muller, Diffraction Tube: complete design and manufacturing drawings and specifications.

1-A-6. Muller, "Rohre E 60/10," Oil Insulated Radiographic and Fluoroscopic Tube: complete design and manufacturing drawings and specifications.

1-A-7. Siemens, (Rudolstadt:) Photographs of substantially all Siemens X-Ray and valve tubes, and description of process for making vacuum bearings.

1-A-8. Siemens, Rudolstadt: Photographs of tube manufacturing, testing, and experimental equipment.

1-A-9. Muller, Anode Casting: Writeup of hydrogen casting of X-Ray tube anodes.

1-A-10. Muller, Thoriated Filaments: Writeup of process for thoriating filaments for valve tubes for X-Ray equipment.

1-A-11. Muller: Photographs of X-Ray tubes and tube heads.

1-A-12. Muller: X-Ray tube Rating Charts.

1-A-13. Seifert, Industrial X-Ray Tubes: Photographs and drawings showing magnetic focusing arrangements, etc.

2-A. <u>Design and Manufacturing Information Covering X-Ray Fluoroscopic and Intensifying Screens and Other "X-Ray Chemicals:"</u>

2-A-1. Siemens (Rudolstadt) Report by Dr. Hartmann, May 15, 1945, covering Manufacturing Processes for all Siemens Screens and "X-Ray Chemicals."

2-A-2. Siemens (Rudolstadt) Photographs of Laboratory and Equipment for Developing and Manufacturing Screens and Other "X-Ray Chemicals."

3-A. <u>Design and Manufacturing Information Covering X-Ray Equipment Other than Tubes, Screens or Chemicals:</u>

3-A-1. Muller, 150 Kv.P., End Ground Industrial X-Ray Tube Head Complete with Focusing Coil, High Tension Bushings and High Tension Cable: complete design and manufacturing drawings and specifications.

3-A-2. Muller, 60 Kv.P., 10 ma., Diagnostic Transformer and Tube Head, Complete with Bracket: complete design and manufacturing drawings and specifications.

3-A-3. Siemens, 75 Kv.P. at 25 ma., (with 80 Kv.P. Inverse Voltage), High Tension Coil, Filament Secondary and Tube Support Assembly: assembly and cross section drawing and winding specifications.

3-A-4. Siemens (Erlangen) Transformer Oil Handling and Processing Information: Report on Siemens procedure.

3-A-5. Seifert, End Ground, Industrial and Other X-Ray Equipment: Photographs showing external and internal construction of transformer and control units, diffraction units and cameras, tube heads, shutters, tube stands, industrial fluoroscopic units, dosimetors and special setups.

3-A-6. Seifert, Diffraction X-Ray Equipment and Other Information: Special writeup, with photographs of Seifert diffraction equipment and other Seifert data.

3-A-7. Seifert, Wiring Diagrams: Wiring diagrams of all Seifert equipment.

4-A. <u>X-Ray Sales Bulletins and Instruction Pamphlets, etc.:</u>

4-A-1. Muller, X-Ray Tube Sales and Technical Bulletins.

4-A-2. Siemens, X-Ray Therapy Equipment Sales Bulletins.

4-A-3. Siemens, Radiographic and Fluoroscopic Equipment Sales Bulletins.

4-A-4. Muller, X-Ray Therapy Equipment Sales Bulletins.

4-A-5. Muller, Radiographic and Fluroscopic Equipment Sales Bulletins.

4-A-6. Muller, Technique Instruction Booklets for Low Powered Radiographic Units.

4-A-7. Muller, Instruction Manual for 150 Kv.P. End Ground Industrial Tube Head.

4-A-8. Muller, Instruction Manual for 60 Kv.P. Transformer and Tube Head.

5-A. <u>X-Ray Technical Articles:</u>

5-A-1. Technical Papers regarding X-Ray Tube and Equipment Design, "Special Set-Ups", Industrial Techniques, etc.

5-A-2. X-Ray Technical Papers regarding Industrial Radiographic and Fluoroscopic Techniques and Equipment.

6-A Electro-Medical (Other Than X-Ray) and Dental Equipment Information:

6-A-1. Booklet, "Die Hochfrequenztechnik in de Medizin," by Johannes Patzold, on High Frequency Techniques in Medicine, including Diathermy, Electro-Surgery, Metal Foreign Body Location, and Supersonic Frequency Nerve Treatment; Published 1943.

6-A-2. Siemens, "Metal-Searcher," (for locating Metal Foreign Bodies): Technical Articles regarding equipment and techniques, technical write-up and instruction manual, wiring diagram and assembly and cross section drawings of probes.

6-A-3. Siemens, "Konvulsator" (Electric Shock Therapy Unit): Technical articles regarding equipment and techniques, instruction manual, and wiring diagram.

6-A-4. Siemens, "Ultraschallgenerator," (Supersonic Frequency Unit for Treatment of certain Nerve Conditions): Description of equipment and instruction manual, photographs of unit, and assembly and cross section drawing of piezo-electric supersonic generator.

6-A-5. Siemens, Electro-Medical Sales Bulletins.

6-A-6. Siemens, Dental "Mechanical" equipment.

7-A Patent Applications and Patents:

7-A-1 Siemens-Reiniger Patent Application and Patent Drawings: Complete set of all Siemens-Reiniger patent application and patent drawings from September 2, 1942 to March 15, 1945; 87 drawings.

7-A-2 Siemens-Reiniger Patent Application and Patent Drawings: Complete set of all Siemens-Reiniger patent applications and drawings from August 2, 1938 to August 5, 1942; 223 drawings

7-A-3. Muller, Patent ebruary 4, 1944 to March 1 ications.

7-A-4. Muller Patent A ne 23, 1943 to November 15, tions.

7-A-5. Muller Patent A Patents: March 9, 1942 to 942; 14 applications and

7-A-6. Muller Patent A Patents: February 7, 194 , 1941; 24 applications

7-A-7. Muller Patent A Patents: February 12, 19 5, 1940; 8 applications

7-A-8. Muller Patent: 39; 1 patent.

7-A-9. Muller Patent A thout Dates; 3 applica

7-A-10. Seifert Patents 35 and November 25, 19

8-A <u>X-Ray Industry Informatic ature:</u>

8-A-1. Philips: Chart n organi- zations owned b ding C.H.F. Muller.

8-A-2. Seifert: Gener production figures; 14 she

9-A <u>Information Relating to "S tage Equipment:</u>

9-A-1. Muller, .9 to 2 on Generators: Te ions, wiring diagrams ngs, beryllium and I ta.

9-A-2. Muller, 300 Kv.P. Rectifier and Surge Supressing Unit for use with Neutron Generators: Assembly and detailed drawings and specifications; 48 sheets.

9-A-3. 1.5 Megavolt, 2 ma., "Van de Graaff Type" Generator: Technical description of installation at Bergen, Norway.